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The Study of Groups: Past, Present, and Future

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A century of research on small groups has yielded bountiful findings about many specific features and processes in groups. Much of that work, in line with a positivist epistemology that emphasizes control and precision and favors the laboratory experiment over other data collection strategies, has also tended to treat groups as though they were simple, isolated, static entities. Recent research trends that treat groups as complex, adaptive, dynamic systems open up new approaches to studying groups. In line with those trends, a theory of groups as complex systems is offered and some methodological and conceptual issues raised by this theory are identified. A 3-pronged research strategy based on theory development, computational modeling, and empirical research that holds promise for illuminating the dynamic processes underlying the emergence of complexity and the ongoing balance of continuity and change in groups is proposed.

As the 20th century ends and the 21st begins, we look back on a century of research on groups, take stock of where the accumulated work of the century has brought us, and look ahead to a possible future for the study of small groups. It is time to reorient our thinking about small groups to make it fundamentally dynamic, to refocus group research on the group as a distinct level of analysis in interaction with other levels, and to take time and history in groups seriously. To reground the study of groups in the reality of group life as it occurs in the world, we must acknowledge and study groups as embedded not only within a hierarchy of levels, from the individual to the interpersonal to the embedding contexts of organizations, networks, and institutions, but also within the passage of time.

We view groups as bounded, structured entities that emerge from the purposive, interdependent actions of individuals. Groups bring together individuals who carry their pasts with them, and groups create their own history, guided by members' sense of the future, as they operate in time. This is not, however, the conception of groups that has guided most research in the past century. It is also not the conception that one would deduce by reviewing most current published studies in social psychology that purport to study groups.

Social psychologists have learned much about phenomena relevant to groups, and also quite a bit about groups, in the past century. However, conceptual and methodological traditions, which in the past have supported advances in our knowledge about groups, have now begun to constrain progress in small-group research. This article adds voice to a persistent chorus of doubts about the current state of small-group research, identifies specific shortcomings grounded in the past that impede advances in the field, and outlines an approach toward setting group research on what is viewed as a more promising path.

To this end, we outline our theory of groups as complex adaptive systems, discuss some of the conceptual and methodological challenges this approach entails, and note some ways of tackling these challenges using new approaches, such as computational

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modeling, established but seldom used research strategies (e.g., experimental simulation), and new approaches within the prototypical research strategy of laboratory experiments. First, however, we discuss in more detail what we see as the challenges posed by the current state of the field, shaped by earlier work in this century.

The Study of Groups in the Past

Small groups have been a topic of interest to social psychologists in both psychology and sociology and to scholars in other social and behavioral sciences for the past century (for recent reviews, see Levine & Moreland, 1990; McGrath, 1997; Moreland, Hogg, & Hains, 1994; Sanna & Parks, 1997). Research in Europe and North America during the 1890s and early 1900s looked at group task performance (Triplett, 1898) and at "coalitions in triads" (Simmel, 1902). A flurry of work in the 1920s investigated social facilitation (e.g., Allport, 1920) and related topics. The field really blossomed, however, in North American social psychology of the 1940s, 1950s, and 1960s, which brought a flood of research on leadership, communication, social influence, conflict, norms, and many other aspects of groups (for reviews of work in this period see Cartwright & Zander, 1953, 1960, 1968; Hare, 1976; McGrath & Altman, 1966). Research on groups within psychology declined dramatically in the late 1960s and 1970s (Steiner, 1974), although related fields such as organizational behavior, communication studies, clinical and educational psychology, and political science remained interested in small groups (Levine & Moreland, 1990).

Contributions and Limitations of Past Research

This body of research on groups contains a wealth of studies and considerable theoretical insight. The field has made great progress in mapping the relative strengths and weaknesses of individuals and groups on different types of tasks, and has developed strong theory and effective techniques of measurement for understanding the transformation of individual inputs into group outputs, focusing on how inputs are combined (Steiner, 1972), how group judgments can be predicted from individual preferences (Davis, 1973, 1982), and why groups often fail to capitalize on the potential resources of members, whether these are creative ideas (Diehl & Stroebe, 1991), unique information (Stasser & Titus, 1985, 1987), or divergent opinions (Asch, 1951).

Social psychologists from the sociology tradition have extended our understanding of power and status relationships in groups (Lovaglia, 1994; Ridgeway & Berger, 1986). We have a better understanding of what creates conflict both within groups (e.g., Jehn, 1995, 1997; O'Connor, Gruenfeld, & McGrath, 1993) and among groups (e.g., Blake & Mouton, 1984; Insko et al., 1992; Sherif, Harvey, White, Hood, & Sherif, 1961). We have attended to cognitive and affective forces, such as identity and cohesion that hold groups together (e.g., Bouas & Arrow, 1996; Hogg, 1987). We have studied how groups influence members, how members influence groups through the leadership process, and how members influence one another (e.g., Bass, 1997; Hackman, 1992; Sherif, 1936).

These insights have been applied to improve group performance in organizations (e.g., Hackman, 1990; for a recent review, see Guzzo & Dickson, 1996), and to change individual attitudes, behavior, and psychological functioning through group discussion, support groups such as 12-step programs, and group therapy (e.g., Kaplan & Sadock, 1993; Yalom, 1995). Studies that have focused on dynamic patterns in group interaction over time have led to formulations about microlevel interaction patterns in communication (Bales, 1950), phase patterns in problem solving and decision making (Bales & Strodtbeck, 1951; VanLear & Mabry, 1999), and developmental patterns reflecting the life course of a group (Gersick, 1988, 1989; Tuckman & Jensen, 1977; Worchel, 1994).

At the same time, the field has been limited by the conceptual and methodological paradigms underlying most of those studies. A large proportion of the research on groups throughout the past century, in social psychology and other fields, has been carried out within a strongly positivistic paradigm. That paradigm emphasizes laboratory experimentation as the privileged research strategy. Much of the work has been laboratory research on ad hoc groups working for short periods of time on tasks arbitrarily assigned to them for experimental purposes. Field studies on "real-life" groups have provided a useful complement, but most field studies have also studied groups as isolated entities and for only short time periods. Social psychologists have typically paid little attention to the groups' embedding contexts. Some recent work in organizational behavior is more sophisticated in this regard (e.g., Morgeson & Hofmann, 1999; Sundstrom, DeMuese, & Futrell, 1990; see Ilgen, 1999, for a good review).

Much of the work that studies interacting groups—especially laboratory experiments—is characterized by four factors that impose serious limitations on the meaning and generality of findings:

1. Groups are studied as if they were simple systems composed of chain-like, unidirectional, cause–effect relations.
2. Groups are studied as if they were isolated from their embedding contexts.
3. Groups are studied as if they were static entities, with no past, no future, and only an input–output present.
4. Groups are studied as generic entities made up of generic people, as though all people and all groups are interchangeable.

By concentrating our empirical research (and our subsequent theoretical formulations) on studies with these features, we have denied ourselves the opportunity to envision groups in ways that more accurately reflect our own experiences in groups—namely, that groups are complex, adaptive, and dynamic systems—and to find ways to incorporate such a viewpoint in our empirical and theoretical research.

The Present

The 1980s and 1990s have seen a resurgence in research on group-related topics in social psychology, inspired by social categorization theory, minority influence theories, and social cognition approaches (Moreland et al., 1994). This stream of research typically focuses on individual cognition about groups or about attitudes ascribed to groups. The group is often an abstraction in the minds of individuals, rather than a collective entity composed of interacting members.

Kurt Lewin is often regarded as the father of small-group research. Yet, in analyzing the impact of Lewin on later group research, Moreland (1996) suggested that Lewin's theoretical emphasis on the individual's subjective perceptions promoted an interest on the individual as a focus within a group setting, drawing attention away from the group as a distinct entity of interest. Hogg (1987) discussed how concepts that were originally thought of as fundamentally group-level constructs, such as cohesiveness, have in practice been reduced to the interpersonal level.

In a thoughtful piece reflecting on the status of experimental research conducted by social psychologists, Månson (1993) concluded that many group experiments actually study something that does not exist: a methodological abstraction that has no equivalent among naturally occurring groups (pp. 274–275). In other words, they study hypothetical entities. Taking this abstraction to a logical extreme, a substantial portion of group studies published in social psychology journals in recent years do not study the behavior of any groups, but focus instead on how people think about hypothetical groups (Moreland et al., 1994). Another subset of studies purport to be about groups, but are actually studies of social interaction or conversation by people who would not define themselves as acting in a group (e.g., Bordia, DiFonzo, & Chang, 1999). In such cases, the group exists not in the concrete operation of a bounded system, or even in the minds of the participants, but only in the mind of the experimenter.

Although studies of actual intragroup processes have become rare in mainstream social psychology journals, such work appears increasingly in organizational psychology and management journals (Sanna & Parks, 1997). Much of this research focuses on extant groups operating in an organizational context, such as cockpit crews, management teams, and quality improvement groups (e.g., Hackman, 1990; Ilgen, Major, Hollenbeck, & Sego, 1995). This work does pay attention to the embedding context of groups and to changes over time, and shows an attention to compositional issues such as gender and ethnic diversity that is lacking in most experimental research. Much of this work focuses on teams, which are defined in contrast to groups in general as having a common group goal.

This work is often informed by a systems metaphor for groups, and a number of organizational researchers have tried to delineate dimensions that distinguish groups or provide a typology of groups. Some have incorporated an "over time" feature of groups as an important feature of their analyses (e.g., Hackman, 1990, 1992). Still, there is not yet a clear and shared theoretical conception about the fundamental properties of small groups in either the organizational literature or the social psychological literature on groups.

Recent work also presents encouraging evidence that dynamic approaches to groups, and to processes that are important to groups, such as social influence, are reemerging in the work of scholars in social psychology (e.g., Latané's 1996 dynamic social impact theory; Nowak, Szamrej, & Latané, 1990), sociology (Polley's 1989 Group Field Dynamics approach), communications (Poole & DeSanctis's 1989 adaptive structuration theory), and organizational behavior (Guastello, 1995). Although dynamical systems and chaos and complexity theory are increasingly providing a source of inspiration and new metaphors for group scholars (e.g., Baron, Amazeen, & Beek, 1994; Latané & Nowak, 1994), the ideas and concepts they are borrowing have not yet been widely and systematically integrated and adapted for application to collective human systems such as groups. Our work (Arrow, McGrath, & Berdahl, 2000) is an attempt to create an integrative, broad theory that can provide a grounding for more work of this nature, so that the trickles of new work can merge into a stream.

Groups As Complex Adaptive Systems

We see groups as complex, adaptive, dynamic systems. Rather than simple, groups are complex entities embedded in a hierarchy of levels and characterized by multiple, bidirectional, and nonlinear causal relations. Rather than isolated, groups are intricately embedded within, and have continual mutual adaptation with, a number of embedding contexts. Rather than static, groups are inherently dynamic systems, operating via processes that unfold over time, with those processes dependent both on the group's past history and on its anticipated future. Groups develop as systems over time, and change as a function of changing conditions over time.

Our approach to studying groups as complex, adaptive, dynamic systems (Arrow et al., 2000; McGrath & Argote, in press; McGrath, Arrow, & Berdahl, 1999) draws on concepts from general systems theory (von Bertalanffy, 1968), from dynamical systems theory (Abraham, Abraham, & Shaw, 1990), and from complexity and chaos theory (Casti, 1992; Kelso, 1995; Prigogine & Stengers, 1984). We present our theory of groups here in skeleton form. We then discuss the implications of this theory for conducting research and describe a combination of research strategies that together hold promise for studying groups in a way that views complexity, adaptation, and dynamic cross-level interaction as essential characteristics of groups.

We regard groups as open and complex systems that interact with the smaller systems (i.e., the members) embedded within them and the larger systems (e.g., organizations, communities) within which they are embedded. Groups have fuzzy boundaries that both distinguish them from and connect them to their members and their embedding contexts.

Throughout a group's life, three levels of causal dynamics continually shape the group. Local dynamics involve the activity of a group's constituent elements: members engaged in tasks using tools and resources. Local dynamics give rise to group-level or global dynamics. Global dynamics involve the behavior of system-level variables—such as norms and status structures, group identity and group cohesiveness, leadership, conflict, and task performance effectiveness—that emerge from and subsequently shape and constrain local dynamics. Contextual dynamics refer to the impact of system-level parameters that affect the overall trajectory of global group dynamics over time, and whose values are determined in part by the group's embedding context. Levels of organizational support, supply of potential members, demand for group outputs, and other extrinsic factors, for example, shape and constrain the local and global dynamics of a group.

All groups act in the service of two generic functions: (a) to complete group projects and (b) to fulfill member needs. A group's success in pursuing these two functions affects the viability and integrity of the group as a system. Thus, system integrity becomes a third generic group function, emergent from the other two. A group's system integrity in turn affects its ability to function effectively in completing group projects and fulfilling member needs, and to adapt to changes in demands and opportunities presented by the environment and by the group members.

Groups include three types of elements: (a) people who become a group's members, (b) intentions that are embodied in group projects, and (c) resources that comprise the group's technologies. Group members vary in what they bring to the group in terms of skills, values, attitudes, personalities, and cognitive styles. They also differ in demographic attributes, and in the needs they seek to fulfill via group membership. Group projects vary in the opportunities for and requirements imposed on members for various kinds of activities. Technologies, which include the "software" tools of norms and procedures as well as "hardware" tools (e.g., hammers, computers, trucks, and musical instruments) differ in what kinds of activity and instrumental functions they facilitate.

Groups pursue their functions by creating and enacting a coordinated pattern of member–task–tool relations that are called the coordination network. The full coordination network includes six component networks: (a) the member network (member–member relationships such as friendship, hostility, and influence); (b) the task network (task–task relations such as their sequencing relations); (c) the tool network (tool–tool relations, such as the need for clustering of particular hardware and software tools); (d) the labor network (member–task relations, which specify who is to do what); (e) the role network (member–tool relations, which specify how members will do their tasks); and (f) the job network (task–tool relations, such as what tools are required to complete particular tasks effectively).

The life course of a group can be characterized by three logically ordered modes that are conceptually distinct but have fuzzy temporal boundaries: formation, operation, and metamorphosis. As a group forms, people, intentions, and resources become organized into an initial coordination network of relations among members, projects, and technology that demarcates that group as a bounded social entity. As a group operates in the service of group projects and member needs, its members elaborate, enact, monitor, and modify the coordination network established during formation. Groups both learn from their own experience and adapt to events occurring in their embedding contexts. If and when a group undergoes

metamorphosis, it dissolves or is transformed into a different social entity.

All three levels of causal dynamics operate, simultaneously and continuously, in all three modes of a group's life. Local dynamics are manifested in a group's coordination processes, global dynamics reflect a group's developmental processes, and contextual dynamics underlie a group's adaptation processes.

Issues and Opportunities Raised by the Theory

Conducting research on the basis of such a conception of groups raises questions about the logic of inquiry, the nature of cause, the role of time in our logic of inference, and the underlying meaning and purpose of empirical studies.

A Different Logic of Inquiry

Our theory, derived by applying concepts in general systems, dynamical systems, and complexity theories to small groups, implies not only a different conceptual perspective but also a different logic of analysis. To summarize, we posit that groups are complex systems. In small groups, local action consists of recursive, nonlinear interaction among many elements. Local group processes create, activate, replicate, and adjust dynamic links in a coordination network. Our conceptualization treats this as an interaction among many local variables. From local action, global-level patterns emerge—behavioral and cognitive patterns (e.g., group norms, cohesion, division of labor, a role system and influence structure) and temporal patterns (e.g., cycles of conflict and consensus, regularities in changing group performance, and the ebb and flow of communication). These global-level patterns are conceptualized as global variables that emerge from the interaction of local variables and then structure subsequent local action.

We can expect local action for any given group to show at least some regularities, which can be modeled as a set of rules that the system follows. Although the interaction among local-level elements may be highly complicated, the rules governing the action and interaction of group elements may be quite simple (e.g., Latané & Nowak, 1994). Which rules guide local action, however, and which global patterns emerge from the operation of these rules, depends on initial conditions and on subsequent situational factors and external conditions, conceptualized here as contextual parameters. This is not the kind of relationship traditionally modeled by independent and dependent variables. Rather, we are talking about contextual factors that constrain the operation of local-level rules without determining the outcome. The whole pattern of global dynamics that emerges from this local action may shift when a contextual parameter shifts to a different value, or it may remain unchanged. This depends on where in the range of possible values the shift occurs.

For example, the overall rate of production of group products (a global variable) may remain constant under a range of external incentives for the group products, but at some point along a continuum of external incentives (the contextual parameter) group members may change their actions, resulting in a shift to a much higher or lower global production rate. Allmendinger and Hackman's (1996) study of East German orchestras, for example, found that differences in local cultures were associated with differences in the orchestras' sex composition, which in turn was associated with differences in member satisfaction and system performance. Their results can be interpreted as showing that local dynamics in the orchestras were shaped in part by the contextual variable of its sex composition, and that there are ranges in composition within which those dynamics are unaffected but also points beyond which a small change (e.g., moving from 30% to 40% women) leads to qualitatively different outcomes.

Given the range of potential interactions among local variables, it is not possible to predict the individual and joint values of these variables accurately, even if their values are known with high accuracy at a particular point in time. Complex systems whose behavior depends largely on interactions among local elements (e.g., the pattern of flight delays at major airports during holiday periods) are only predictable in the short run, and these predictions are for global variables, not local variables. Patterns of key global variables, however, do show substantial regularities over time. The qualitative pattern of these regularities may differ for groups under different operating conditions, or for the same group if the value of a contextual parameter changes beyond some critical threshold. The pattern over time of a given global variable such as the division of labor, for example, may be qualitatively different (e.g., centralized or decentralized), depending on the setting of a contextual parameter (e.g., the level of external threats to the group).

In the language of dynamical systems, global variables settle over time into relatively small regions in state space (the space of possibilities for that variable). These regions, called *attractors*, vary in type. One focus of research in this approach is to identify the attractor or attractors into which a global variable will settle

over time. Those attractors may be single or multiple, stable or unstable, fixed point or periodic, or some other form. The configuration of attractors is also likely to vary at different levels of key contextual parameters. For example, if conflict is taken as a global variable, one group (the alpha team) may have a single, stable, fixed point attractor of moderate conflict. This is the value for conflict the group settles into and maintains. This configuration holds over a range of values for external stress (a contextual parameter) on the group. At very high levels of stress, however, a new pattern may emerge, with two unstable attractors of either very high conflict or very low conflict. Another group (the beta team) may have a stable periodic attractor for conflict—a consistent pattern of increasing, then decreasing, conflict—that persists over a wide range of stress levels. At very high stress, however, the beta team shifts to a single, stable, fixed point of high conflict.

It is not the aim of this approach, therefore, to predict average levels of specific local variables, either at a given time or aggregated over time. Rather, the aim is to track the characteristic evolution of the system through different system states, as reflected in the pattern of global variables over time, and to investigate which contextual parameters affect this pattern of evolution, and how.

Temporal Issues

Groups are characterized by the simultaneous operation of multiple temporal processes, with potentially different cadences and cyclic forms. Some of those group processes may operate differently depending on where the group is in its historical life cycle. So, too, many extrinsic contextual factors may have different effects depending on where in the group's life they occur. Some of the temporal processes that underlie group operations may arise from the nature of the projects the group is undertaking. These, of course, will differ for groups of different kinds. At more microlevels, executing the tasks that make up group projects often requires precise synchronization of the timing of different actions by the same member and of actions of different members. Consider, for example, that the actions of every member of an orchestra must be synchronized at the temporal level of a 16th note!

Such synchronization requirements suggest that the concept of entrainment of multiple cyclical processes is useful not only for studying biological systems but also for analysis of social systems such as groups. Entrainment refers to the synchronization, in phase and periodicity, of multiple cyclical processes or behaviors. At the biological level, the most well-known set are the circadian rhythms, multiple biological and chemical processes that become synchronized with one another and with the day–night cycle of the planet. At the individual and group behavior level, researchers have found evidence for entrainment in task production rates, interaction patterns, communication timing, and even breathing patterns, for interacting partners and groups (e.g., Ancona & Chung, 1996; Karau & Kelly, 1992; Kelly, 1988; Kelly & McGrath, 1985; McGrath & Kelly, 1986; Warner, 1979). Such complex synchronization also suggests the need to develop methods for data collection, analysis, and interpretation that will let us tease apart such multiple overlapping rhythmic processes and assess their effects.

Causal Issues

A complexity theory view also invites us to raise questions about the nature of causality. Traditionally, small-group research, like most work done in the positivistic tradition, has primarily focused on efficient (also called mechanical) cause. Moreover, it has treated that form of causation as consisting of a series of directional, linear, chain-like cause–effect connections between two (or very few) specific variables. The very idea of complex systems carries with it the implication that the causal connections (at the level of local dynamics) are multivariate, bidirectional, and nonlinear relations. Moreover, the emphasis in complexity theory on developmental processes suggests the importance of formal cause—the way in which process constrains or determines structure. Furthermore, human systems—such as groups—are strongly characterized by the operation of *intentionality*: Individuals and groups do what they do, sometimes and to some extent, because they intend to do so. This is a kind of final cause.

Some Methodological Issues

Not only does a complex system view of groups carry with it a different logic of analysis but also argues for changes in the traditional methods of studying groups. This approach calls for greater use of within-group designs, along with (or really, nested within) our more customary between-group designs. It also suggests the need to change our view of some of the features of designs that have traditionally been considered methodologically problematic (e.g., threats to internal validity, such as history and maturation; Cook & Campbell, 1979). These are, instead, inherent features of groups that persist as systems over time; hence, they are aspects of the phenomena

to be studied rather than threats to be eliminated via design and analysis.

The complexity theory view of groups also raises some further methodological issues. It tends to blur the distinctions between nomothetic and ideographic purposes, as well as the distinction between prediction and control versus description and understanding as the bedrock purposes of science. It also invites questions about whether our practice of aggregation and averaging a series of successive measurements as a means for elimination of random error of measurement is in fact a practice that discards information about the functioning of the measured systems over time.

The Future: Where Will We Go From Here?

As is apparent from the previous discussion, it is one thing to talk about a new theoretical view of groups, one that questions some of the field's most entrenched operating assumptions, but it is quite another to formulate a viable and useful research program by which to explore, test, and modify that theory. We suggest that, in the future, effective research on small groups will require major shifts in methodological preferences within our current paradigm (e.g., shift to more emphasis on research dealing with "natural groups" over extended periods of time), as well as major extensions or modifications of that research paradigm (e.g., to shift the object of analysis from average differences in aggregated scores between conditions to tracking the trajectory of global variables over time for groups operating under comparable initial conditions). Such shifts in preferences and paradigms imply major change in our methodology at strategic levels.

This prescription poses enormous challenges for those who wish to extend and redirect future research on small groups. By no means do we believe that we have adequate answers to those challenges at this time. We do, however, have some suggestions for a systematic effort toward meeting those methodological challenges, stemming in part from experience gained and lessons learned in our own research endeavors.

Specifically, we suggest that one can make a good beginning toward meeting these methodological challenges by adopting a tripartite research strategy, consisting of (a) a comprehensive theory of groups as complex adaptive systems, (b) an eclectic and flexible approach to empirical research, informed by theory and by existing empirical findings, and (c) computational models that connect theory and empirical research by enabling researchers to develop complex sets of theoretical relations and explore their implications over time. Results from work on each of these three fronts—theory, empirical research programs, and computational modeling—should inform further developments in the other two, with a continual need to adjust all three. The theory should be based at the outset on the body of extant empirical evidence and should provide the basis for both the design of new empirical studies and the development of computational models. The theory needs to be reexamined and modified continuously, in light of empirical findings about how people behave in groups and on the basis of computational model output that reveals how the theory behaves when translated into a set of rules and formulas and run over time.

The body of extant empirical evidence offers both the basis for initial theorizing and for setting initial parameters and variables for computational models. New empirical evidence, derived from studies designed to explore the implications of the theory and to verify the output of the computational models, can serve as the crucible in which both theory and model are assessed. Some of this data may be generated by experiments in familiar laboratory settings, looking at dynamics over the short term. Some may be generated by extended experimental simulations, such as the semester-long JEMCO studies (for overviews, see Arrow et al., 1996; McGrath, Arrow, Gruenfeld, Hollingshead, & O'Connor, 1993), which examined the patterns of behavior for multiple groups over time. Some may be generated by comparative field studies of naturally occurring groups over time, as exemplified by the comparative case studies published in Hackman (1990).

Laboratory Experiments

Certain criteria are crucial for studying groups as complex dynamic systems using laboratory experimentation. In those studies it is essential that (a) groups consist of real people interacting over time, rather than isolated individuals making judgments about hypothetical others or groups; (b) key local and global variables are tracked over time rather than measured once or twice; and (c) the researcher examines the trajectories of global variables for each group to look for dynamic patterns, rather than aggregating across groups on the presumption that any variations among those groups are random error masking a single true trajectory for all groups. If we take group composition and group history seriously, we must acknowledge that all real human groups, whether formed in the laboratory or sought out in the field, differ in initial conditions because they are made up of different people, and that as each group develops,

it acquires a history that distinguishes it to some extent from other groups of similar membership composition, task, and tools. Studying interacting groups requires the abandonment of some of the control and precision that is a hallmark of experimental research, while preserving the ability to manipulate some of the variables that will affect dynamic processes in groups.

An example of this approach, which looks at short-term dynamics in the laboratory, is a paradigm developed by Arrow and colleagues (Arrow, Bennett, Crosson, & Orbell, 1999) to study the self-organized formation of groups. In contrast to the typical approach to composing groups, in which participants are randomly assigned to groups, participants in the "social poker" paradigm are assembled together, given resources (playing cards) and information about the resources of other players (the cards other players have received) and then must form groups and pool their cards to make a standard card hand such as four-of-a-kind. Different hands earn different amounts of money, and group members must decide how to divide up the proceeds. After groups are formed, players turn in their cards, receive new cards, and must again form groups.

This paradigm is designed to study the stream of individual choices and the intersection and coordination of those choices in a dynamic environment, which results in the formation of ephemeral coalitions (short-lived acting groups) and, if the same members repeatedly seek one another out, the emergence of standing groups and group structures such as allocation norms. Once the range of dynamic patterns is identified for repeated replications in the same condition, extrinsic parameters believed to affect the emergence of relatively stable groups (e.g., the stability of the incentive structure and the demographic composition of the pool that members are drawn from) can be systematically varied to see if different sets of trajectories emerge for global variables such as the rate of membership change, allocation norms, and status hierarchies among players.

Computational Modeling

Computational models, based initially on the premises of a theory and the evidence from extant empirical data, can test a very wide range of possibilities implied by the theory that would be difficult to test empirically (e.g., Carley & Svoboda, 1996; Drogoul & Ferber, 1994; Gordon, Goodwin, & Trainor, 1992). They can do so both with large samples of runs that have identical initial conditions and with large samples of runs that start with different initial conditions. Inclusion of stochastic events in the computational model will allow simulated groups starting from identical initial conditions to develop different histories, and thus the range of plausible trajectories given a particular set of starting conditions can be mapped.

For example, Berdahl (1998, 1999) developed a computational model of a general, dynamic, and testable theory of small groups that drew on past group research (e.g., Moreland & Levine, 1982; Steiner, 1972). The model was designed in particular to study demographic diversity in groups by exploring the implications of different theories regarding whether and how initial evaluations of members' skills are influenced by demographic cues (Berdahl, 1996). In its current form, the model simulates one fully staffed, four-person group for 20 time periods, whose members remain in the group and do not recruit new members. Several parameters can be manipulated, including (a) group project types; (b) member skills, needs, and demographics; (c) members' initial evaluations of each other's skills; and (d) the degree to which skills, needs, and evaluations change over time. The model makes predictions for group performance, divisions of labor, member commitment to groups, group commitment to members, and member power.

In an initial study, Berdahl (1999) ran thousands of cases of four-person groups, varying how members initially evaluated each other's skills, the demographic composition of the groups, and the procedure for developing a division of labor within the group. The runs contained stochastic elements, including random variation in members' skills from case to case (as though groups were staffed from a population with normal distributions of skills).

Several results from the initial runs highlighted the utility of computational modeling for combining several group parameters into one theoretical treatment, and for illustrating counterintuitive consequences of the complex interaction of several simple but simultaneous rules for group interaction. For example, initial evaluations of member skills had less of an impact than suggested by traditional theories of diversity that fail to incorporate other member characteristics and group processes into their predictions. In addition, groups using an equity norm for allocating assignments and opportunities to their members had significantly worse outcomes than groups using an equality norm. Results also helped highlight problematic implications of the conception of member power used in the model.

These runs systematically mapped a portion—although only a small portion—of the total conceptual space defined by all the combinations of all possible values of the variables of the computational model. Data generating on this scale simply cannot be accomplished by empirical studies of any kind, al-

though empirical studies are essential to investigate whether dynamic patterns that emerge in the computational runs will also appear in real groups. Computational modeling can also be used to assess the theoretical consequences of some possibilities that could not be put to empirical test at all for ethical or practical reasons.

The discussion and examples given in this article are focused on agent-based computational models. Much of our argument applies, as well, to computer simulations more generally. Such simulations often model the operation of the system as a whole directly. It seems, however, that agent-based, object-oriented computational models offer an especially useful tool for modeling the emergence of system level properties from the simulation of local level agents and relations.

Concluding Comments

In sum, future research on small groups would profit if scholars in that area were to adopt the following perspectives on their work:

1. Take into account the idea that groups are dynamic, adaptive, complex systems with multiple forms and levels of causality operating simultaneously, and choose and develop research strategies and tactics appropriate to that recognition.
2. Study groups both at the group system level, and at the level of interchanges between groups and their embedded systems (members) and among groups and their embedding systems (e.g., organizations, communities).
3. Accept the idea that not all entities that fit a general definition of groups are alike, and develop useful classification and taxonomic systems that permit us to make useful distinctions among different types of groups. Work is needed at intermediate levels (not so particular that each group is a separate type, but not so general that families, boards of directors, basketball teams, friendship groups, and steel puddling crews are expected to be responsive to the same general laws).
4. Take variation in member characteristics seriously, and adopt conceptual and methodological strategies that can deal effectively with simultaneous patterning on multiple attributes. Learn to study effects of homogeneity and various patterns of diversity on multiple attributes, at different levels of accessibility.
5. Take into account that much that is interesting about groups develops over time, and with time comes changes in members, projects, technology, and context. Develop both conceptual and methodological tools to study systems that are undergoing change. Recognize the importance both of the past and of the future on group structure and behavior, and learn to study groups that are not static and unchanging systems.

Small groups will continue to be the context for much of human social experience, in families and in organizations, at work and play. Hence, they will be important topics of study for social psychology and for other social and behavioral sciences. Although a lot has been learned in the past century, the heavily positivistic experimental approach that has driven much of that work, and the body of theory and evidence derived from that work, is largely based either on the implicit premise that groups are simple, separate, static entities, or on the premise that social interaction and interpersonal processes in general subsume all that is interesting about groups. The field seems to have reached the limits of what one can learn without developing a unifying conception of the group that recognizes the complex adaptive nature of groups, attends to phenomena that arise from but are not reducible to individual and interpersonal processes, and draws on methodology appropriate for exploring that dynamic, adaptive nature.

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